



# Prevalence and Location of Acetabular Sublabral Sulci at Hip Arthroscopy with Retrospective MRI Review

Daniel Saddik<sup>1,2</sup>  
 John Troupis<sup>2,3</sup>  
 Phillip Tirman<sup>4</sup>  
 John O'Donnell<sup>5</sup>  
 Robert Howells<sup>5</sup>

**Keywords:** hip anatomy, hip arthroscopy, labral sulci, MRI, musculoskeletal imaging

DOI:10.2214/AJR.05.1465

Received August 20, 2005; accepted after revision November 12, 2005.

<sup>1</sup>Department of Radiology, The Northern Hospital, 185 Cooper St., Epping, Victoria 3076, Australia. Address correspondence to D. Saddik (racdan@inet.net.au).

<sup>2</sup>Symbion Health Limited, Melbourne, Victoria, Australia.

<sup>3</sup>Department of Radiology, The Epworth Hospital, Richmond, Victoria, Australia.

<sup>4</sup>California Pacific Medical Center, San Francisco, CA.

<sup>5</sup>Orthopedic Clinic and Mercy Health, East Melbourne, Victoria, Australia.

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AJR 2006; 187:W507–W511

0361–803X/06/1875–W507

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**OBJECTIVE.** The objective of this prospective study was to determine the prevalence and location of acetabular sublabral sulci diagnosed as variants at hip arthroscopy and to provide a retrospective MRI review.

**SUBJECTS AND METHODS.** Two experienced hip arthroscopists noted the prevalence and location of acetabular labral sulci in 121 patients. The study population consisted of 57 males and 64 females with an average age of 43 years (range, 16–70 years). Of the 121 hip arthroscopies that showed sulci (22% of patients), correlation with the relevant MR studies ( $n = 27$ ) was performed. Two radiologists who were aware of the arthroscopic findings reviewed the MR studies retrospectively, and agreement on imaging appearances was reached by consensus.

**RESULTS.** Arthroscopy revealed 30 sulci (25%) in 27 of the 121 patients. In those who had a single sulcus (25 patients), 11 (44%) were located anterosuperiorly, 12 (48%) posteroinferiorly, one (4%) anteroinferiorly, and one (4%) posterosuperiorly. The other two patients had more than one sulcus: one patient had one posterosuperior sulcus and one posteroinferior sulcus; and the other patient had one anterosuperior sulcus, one anteroinferior sulcus, and one posteroinferior sulcus. In total, of the 121 patients, the number and position of the sulci were 12 anterosuperior (10%), 14 posteroinferior (12%), two anteroinferior (2%), and two posterosuperior (2%). Of the 27 MR examinations, 24 were unenhanced and three studies were performed after intraarticular injection of gadolinium. In these 27 patients, a total of 30 sulci were detected at arthroscopy. On retrospective MR review of both the conventional and gadolinium-enhanced studies, nine (75%) of the 12 anterosuperior sulci could be visualized. Ten (71%) of the 14 posteroinferior sulci were also identified. Neither of the two anteroinferior sulci could be seen. Both of the posterosuperior sulci were evident. Of the conventional MR studies, of a potential of 27, 18 (70%) were identified on conventional imaging.

**CONCLUSION.** Sulci of the hip exist (22% of patients) and can be found at all anatomic positions (i.e., anterosuperior, anteroinferior, posterosuperior, and posteroinferior) of the hip. These sulci can be visualized on MRI with an accuracy of 70% using a nongadolinium technique.

**A** labral tear is a cause of groin or hip pain (or both) and is a well-recognized indication for diagnostic and therapeutic hip arthroscopy. The underlying causes include acetabular dysplasia or lateral acetabular rim syndrome, trauma, and femoroacetabular impingement [1, 2]. Some studies have shown that the most accurate way of imaging labral abnormalities is using MRI and, in particular, gadolinium-enhanced MR arthrography [3, 4]. However, a potential pitfall in the correct identification of labral tears at MRI and MR arthrography is the anatomic variations of an acetabular sublabral sulcus, which can be seen at different locations.

There is controversy about the existence of the sublabral sulcus. Some studies have

found no evidence of labral sulci, whereas the authors of others speculate about, suggest, or support its existence [5–14]. There are also differing opinions about the position of the sulcus—that is, whether it occurs anterosuperiorly or posteroinferiorly.

The purpose of this study was to determine the prevalence and location of sulci prospectively on arthroscopy in patients with a clinical suspicion of a labral tear and to provide MR correlation.

## Subjects and Methods

Over a 1-year period, 121 patients underwent hip arthroscopy because of clinical suspicion of a labral tear. The study population consisted of 57 males and 64 females with an average age of 43

years (range, 16–70 years). In addition to noting hip abnormalities, the arthroscopist prospectively recorded the presence of a sulcus and its site (defined as anterosuperior, anteroinferior, posterosuperior, or posteroinferior). This information was documented on written reports and shown in diagrams and on photographs.

Two experienced arthroscopists performed the procedures. One had performed more than 2,000 and the other more than 1,000 previous hip arthroscopies.

A sulcus was defined arthroscopically as a well-defined cleft between the labrum and the adjacent articular (hyaline) cartilage in which the labral edges were smooth, there were no signs of attempted healing, and there was no labral displacement on probing. These findings are in contradistinction to those associated with a tear, which shows labral fraying, has irregular edges, and is unstable on probing.

All relevant MR studies ( $n = 27$ ) were retrospectively assessed by two experienced (fellowship-trained) musculoskeletal radiologists. A consensus opinion was reached between the radiologists in determining the presence of a labral sulcus. A sulcus was said to be present on MRI if a cleft was clearly visualized between the labrum and its cartilage attachment on at least one image and if these findings correlated with the arthroscopic findings. The position of the sulcus was defined as anterosuperior, anteroinferior, posterosuperior, or posteroinferior.

The MR examinations were all performed on a 1.5-T magnet (Signa, GE Healthcare). A cardiac coil was used. The imaging protocol for both the conventional and gadolinium-enhanced studies included three imaging planes. The parameters for the conventional study were spin-echo proton density-weighted sequences (TR range/TE range, 2,800–4,100/24–35) in the axial oblique, coronal, and sagittal planes and a spin-echo T2-weighted sequence with fat saturation (3,400–4,100/40–52). For intraarticular gadolinium-enhanced MRI, the parameters were a spin-echo T1-weighted sequence with fat saturation (400–900/10–15) in the axial oblique, coronal, and sagittal planes and a spin-echo T2-weighted sequence with fat saturation (3,400–4,100/40–52) in the coronal plane. The field of view was 16–18 cm; slice thickness, 3–4 mm; and gap, 0–1 mm. The number of acquisitions was 2–3. The matrix range was 320–384 × 192–256. The intraarticular injection consisted of 3 mL of iodinated contrast agent and 7 mL of diluted gadolinium (gadopentetate dimeglumine [Magnevist, Schering]) at a concentration of 3 mmol/L.

## Results

Arthroscopy showed 99 (82%) of the 121 had labral tears or detachment. Of these 99 cases, 89 (90%) were located anteriorly or anterosuperiorly, three (3%) both anterosuperiorly

and posterosuperiorly (contiguous tear), another three (3%) were noted posterosuperiorly only, and four (4%) anteroinferiorly only. Eighteen (67%) of 27 patients with sulci had labral tears (Table 1).

On review of prospective MRI reports in those patients who had no labral tear seen on arthroscopy, four patients had sulci (three anterosuperior and one posteroinferior) that were incorrectly reported as labral tears. No sulci were reported prospectively on MRI.

Arthroscopy revealed 30 (25%) sulci in 27 of the 121 patients. In those who had a single sulcus (25 patients), 11 (44%) were located anterosuperiorly, 12 (48%) posteroinferiorly,

one (4%) anteroinferiorly, and one (4%) posterosuperiorly.

The other two patients had more than one sulcus: one patient had one posterosuperior sulcus and one posteroinferior sulcus; and the other patient had one anterosuperior sulcus, one anteroinferior sulcus, and one posteroinferior sulcus.

In total, of the 121 patients, the number and position of sulci were 12 (10%) anterosuperior, 14 (12%) posteroinferior, two (2%) anteroinferior, and two (2%) posterosuperior.

All sulci were only partially separated from the underlying cartilage. No cartilage undercutting was detected at arthroscopy.

Of the 27 MR examinations, 24 were non-gadolinium and three were studies performed after the intraarticular injection of gadolinium. In these 27 patients, a total of 30 sulci were detected at arthroscopy. In only two (8%) of the 24 nongadolinium studies was an effusion present.

On retrospective MRI review of both the conventional and gadolinium-enhanced studies, in total, nine (75%) of the 12 anterosuperior sulci (Figs. 1A and 1B) could be visualized. Ten (71%) of the 14 posteroinferior sulci (Fig. 2) were also identified. Neither of the two anteroinferior sulci could be seen. Both of the posterosuperior sulci (Fig. 3) were evident. Of the conventional MR studies, of a potential of 27, 18 (67%) were identified on conventional imaging. Three (100%) of three were visualized with gadolinium-enhanced imaging (Tables 2 and 3).

Sulci were generally more easily visualized on the proton density- and T1-weighted sequences rather than on the T2-weighted sequences. The anterosuperior and posterosuperior sulci were best depicted in the coronal plane. The posteroinferior sulcus was best seen in the axial oblique plane. All sulci on MRI except one showed a sharply defined labrum.

## Discussion

There has been controversy in the literature about whether acetabular labral sulci exist and, if they do exist, at which location they occur. In this large study, sulci were diagnosed arthroscopically by experienced surgeons. Sulci were found at all anatomic positions (anterosuperior, anteroinferior, posterosuperior, and posteroinferior), and some could retrospectively be visualized on MRI.

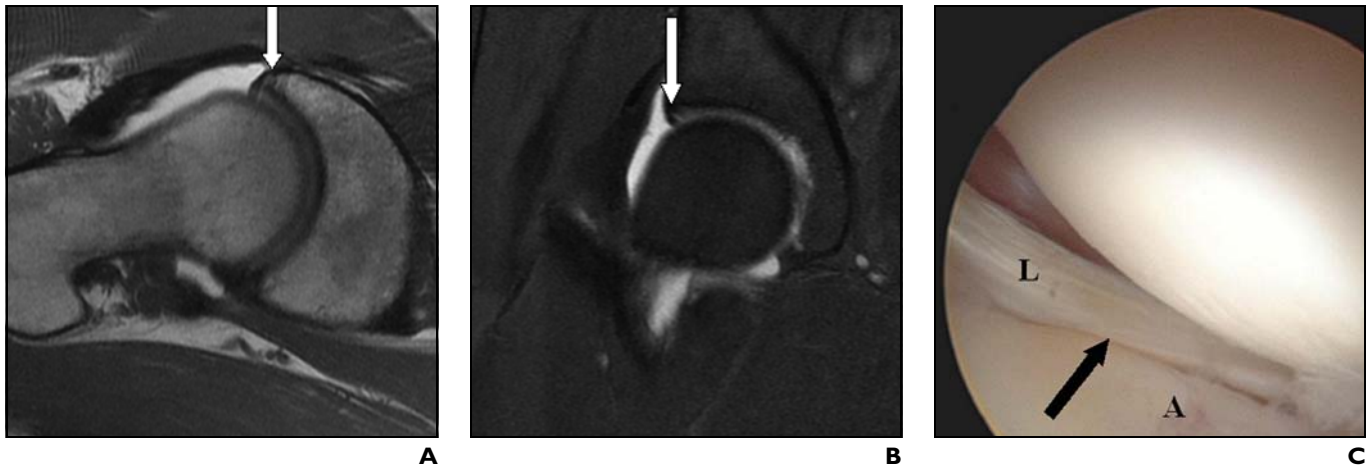
In several previously published articles, researchers have found no evidence of labral sulci. This lack of evidence may reflect small sample sizes, in vitro rather than in vivo stud-

**TABLE 1: Arthroscopic Association of Sulci and Labral Tears in 27 Patients**

Patient No.	Arthroscopy Finding	
	Sulcal Location	Associated Labral Tear
1	AS	None
2	AS	None
3	AS	None
4	AS	None
5	AS	None
6	AS	None
7	AS	None
8	AS	PS
9	AS	PS
10	AS	AI
11	AS	AI
12	PI	AS
13	PI	AS and AI
14	PI	AS
15	PI	AS
16	PI	None
17	PI	AS
18	PI	AS
19	PI	AS
20	PI	AS
21	PI	AS
22	PI	AS
23	PI	AS
24	AI	AS
25	PS	AS
26	PS and PI	AS
27	AS, AI, and PI	None
Total	30 Sulci	19 Tears

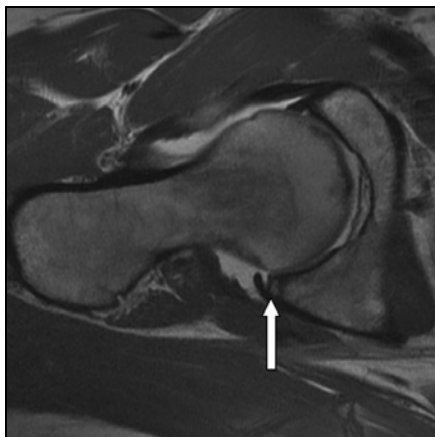
Note—AS = anterosuperior, PS = posterosuperior, AI = anteroinferior, PI = posteroinferior.

## Acetabular Sublabral Sulci at Hip Arthroscopy



**Fig. 1**—49-year-old woman with anterosuperior labral sulcus that was preoperatively misinterpreted as labral tear.

**A**, Oblique axial T1-weighted image obtained after intraarticular injection of gadolinium shows partial detachment of anterosuperior labrum from adjacent cartilage (arrow). **B**, Coronal T2-weighted image obtained after intraarticular injection of gadolinium shows partial detachment of anterosuperior labrum from adjacent cartilage (arrow). **C**, Arthroscopy image corresponding to **A** and **B** shows sharply defined labrum (L) with adjacent sulcus (arrow) between labrum and cartilage (A).



**Fig. 2**—28-year-old man with posteroinferior labral sulcus that was not commented on preoperatively. Oblique axial T1-weighted image obtained after intraarticular injection of gadolinium shows partial detachment of posteroinferior labrum from adjacent cartilage (arrow).

ies, not recording the presence of a normal finding, and using hip arthrotomy and not arthroscopy (the latter affording a better evaluation of the labrum) [5–7].

A paucity of articles in the radiology literature and arthroscopy literature speculate about, suggest, or support the presence of normal sulci.

Byrd [8], in a hip arthroscopy review published in 1996, only briefly referred to sulci: "...partial separation of the labrum from the lateral aspect of the bony acetabulum has been found to often be a normal anomalous variation." An accompanying image in that article showed an anterosuperior sulcus. In a

follow-up review article on hip arthroscopy, Byrd [9] stated that labral sulci are common without mentioning a specific location.

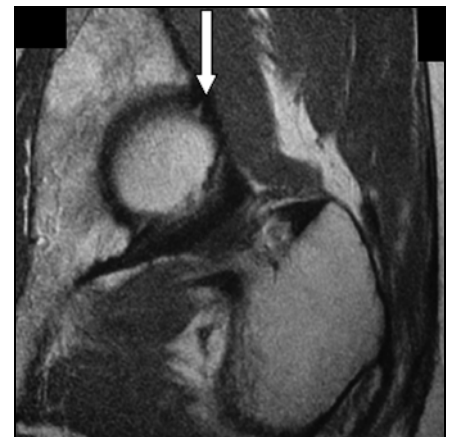
Petersilge [10], in a review article on MR arthrography of the hip, stated that an anterosuperior sulcus is present and that it is not an uncommon finding. In her view, the sulcus is sharply defined and is only partially separated from the bony acetabulum. However, in that article, this statement is followed with "no scientific evidence exists to support this" [10].

In an article published in 1981 about a fetal labral specimen study, anterosuperior sulci were identified [11]. Interestingly, these sulci were seen only at light microscopy and could not be seen on visual inspection. This discrepancy in findings raised the possibility of "fixation" artifact and doubts about the validity of the findings. In addition, extrapolating findings obtained from a study of a fetus to the adult may also reduce the usefulness of this study.

Marianacci et al. (Marianacci EB et al., presented at the 1995 annual meeting of the Radiological Society of North America) described a single case of a normal sublabral sulcus that was confused with a labral tear on MR arthrography with operative proof. The significance of a single case is uncertain.

In two asymptomatic volunteer studies [12, 13], researchers speculated about the presence of sulci, but in neither article was there operative correlation.

Keene and Villar [14] retrospectively reviewed images obtained from second hip arthroscopies in 100 cases to describe the normal anatomy of the labrum in an article



**Fig. 3**—40-year-old man with posteroinferior labral sulcus that was not commented on preoperatively. Coronal proton density-weighted image reveals partial detachment of posteroinferior labrum from adjacent cartilage (arrow).

published in 1994. In that article, they show an example of a posteroinferior sulcus. They did not specifically describe a sulcus (nor illustrate one) elsewhere.

Interestingly, it was not until recently that Dinauer et al. [15] presented findings from a retrospective study showing MR correlative examples of arthroscopically proven posteroinferior sulci. Although Dinauer et al. should be commended for their excellent and timely article, the point that we believe needs to be emphasized is that in our experience an isolated tear of the posteroinferior labrum is rare, and we have not seen it outside the setting of a posterior hip dislocation. Several arthro-

**TABLE 2: Arthroscopic Versus Conventional MRI Findings**

Location of Sulcus	No. (%) of Patients with Sulcus	
	Detected at Arthroscopy	Retrospectively Visualized on Conventional MRI
Anterosuperior	11 (41)	7 (39)
Posterosuperior	2 (7)	2 (11)
Anteroinferior	2 (7)	0 (0)
Posteriorinferior	12 (44)	9 (50)
Total	27 (100)	18 (100)

**TABLE 3: Arthroscopic Versus Contrast-Enhanced MRI Findings**

Location of Sulcus	No. (%) of Patients with Sulcus	
	Detected at Arthroscopy	Retrospectively Visualized on Gadolinium-Enhanced MRI
Anterosuperior	2 (67)	2 (67)
Posteriorinferior	1 (33)	1 (33)
Total	3 (100)	3 (100)

scopic studies support the rarity of this finding [16, 17]. In view of this, the radiologist can, in our opinion, be comfortable ignoring a cleft in the posteriorinferior labrum in virtually all cases. We do, however, recognize that variations do exist among people from different regions. In Japanese patients, for example, labral tears have been found more posteriorly than anteriorly [18].

In agreement with Keene and Villar [14], Dinauer et al. [15] found no sulci elsewhere. However, it should be noted that the latter was a retrospective study in which the presence of a sulcus was not specifically addressed at the time of arthroscopy, and information was obtained from available arthroscopic photographs.

Even allowing for these limitations, there was a clear discrepancy between the findings from previous studies and our findings in which anterosuperior, anteroinferior, posterosuperior, and posteriorinferior sulci were detected.

Patient selection bias could account for this discrepancy in findings. Additional factors include the larger population in our study and the fact that it was prospective and specifically targeted labral sulci. Another factor is that 94% of patients in the Dinauer et al. [15] study had anterior or anterosuperior labral tears, the latter site a place where we found

sulci. We hypothesize that tears had occurred at the site of what was previously a sulcus, thus obscuring the latter. Dinauer and colleagues do allude to this possibility, but on retrospective review of intraoperative photographs, they explain that they found no “definite surgical evidence of both a sublabral sulcus and labral tear in the same region of the acetabulum.” We argue that in this setting it may be difficult to separate the two.

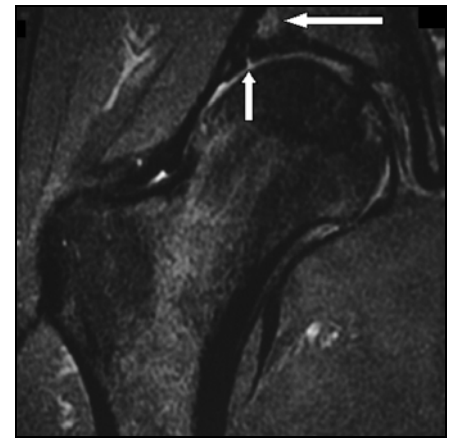
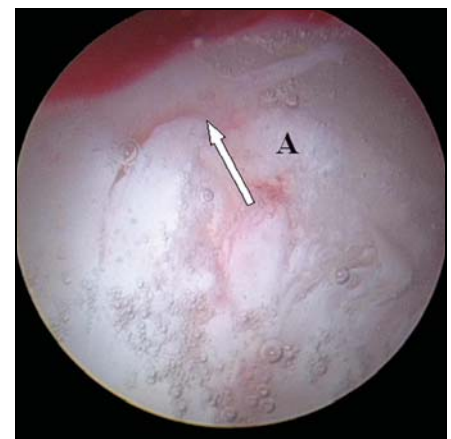
The anteroinferior sulcus, although proven on arthroscopy, was not visualized on MRI. Of the anterosuperior and posterosuperior sulci, 75% and 71%, respectively, were identified on MRI. The absence of visualization of proven sulci on review of the MR studies may reflect the small size of the labrum and incomplete detachment.

All sulci shown on MRI, except one case, showed a sharply defined labrum, with only partial separation from its attachment. Unfortunately, in our experience, proven pathologic labral detachments may also show the same MRI findings. The absence of a visualized “ragged” labral border with a labral tear (Fig. 4) could reflect the small size of the labrum (diminished resolution) and that using microcoils for imaging of the hip does not show the hip well enough.

There were several limitations of our study. One was patient selection bias. All our patients were symptomatic, with mechanical hip pain, and had a clinical suspicion of a labral tear. This therefore resulted in an inherent surgical bias toward the finding of a labral tear. If we accept the premise (as discussed earlier) that labral tears may obscure sulci at the same region of the labrum, then the prevalence of labral sulci may also be affected.

Another potential limitation is the use of unenhanced MRI. However, we have shown that sulci can be visualized on MRI without (and with) gadolinium. We do not routinely use intraarticular gadolinium because we believe that it is usually not necessary and because our referring surgeons have a strong bias against its use. In addition, in a recent article, unenhanced MRI was shown to be accurate in determining the presence of a labral tear [19]. Given that a labral tear may have an appearance that is similar to that of a sulcus, one may speculate that a gadolinium-enhanced MR study may not contribute further information. Because of the small number of patients who had enhanced studies, our article does not address this issue.

In conclusion, acetabular labral sulci not only exist and are located anterosuperiorly, anteroinferiorly, posterosuperiorly and posteriorin-

**A****B**

**Fig. 4—25-year-old man with anterosuperior labral tear. A, Coronal T2 fat-saturated image shows partial detachment of anterosuperior labrum from adjacent cartilage (short arrow). Note subtle marrow edema of adjacent acetabulum (long arrow). B, Arthroscopy image corresponding to A shows torn detached labrum (arrow) from acetabular cartilage (A).**

feriorly, they can be visualized on MRI in 67% of cases using a nongadolinium technique.

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